CHAPTER I

RADIO BROADCASTING INTERFERENCE

General

The radio broadcasting interference is the radiated interference which is transmitted by electromagnetic fields from the radio transmitters and/or the other sources of RF energy such as natural static (Atmospheric), artificial static (man-made), and etc.

The radio transmitter convert sound waves to electrical impulses. The electrical impulses that represent the original sound waves are sent out by the use of high-frequency alternating currents. This currents produce magnetic and electric fields that radiate in all directions over long distances without losing much of their original strength.

The radio interference passess through a "Receiver" as an undesired signal when the desired signal is absent and as a parasite when the desired signal is present. Thus, the receiver receives sound and noise, or desired functions and undesired malfunctions. This dual response reduce the speed of telegraphy, the intelligibility of speech, the appreciation of music, the clearness of images, or the accuracy of mechanisms. A high interference level lowers the range of a receiver for a given quality of reception from a transmitter of a given power.

A radio transmitter may radiate unnecessary frequency or frequencies which are outside the necessary bandwidth. These unnecessary frequency or frequencies due to the distortion of the modulation, harmonics of the carrier frequency, etc. Any of these radiated frequencies, necessary or otherwise, may cause interference in various ways.

Bandwidth of the Transmitter

It is necessary that the system of the radio broadcasting transmitters transmit only those frequencies in a necessary bandwidth. Necessary bandwidth is defined as that minimum bandwidth necessary to sufficiently insure the transmission of intelligence at the rate and with the quality required for the system employed.

It has been frequently stated that the A-M broadcast transmitters are restricted to the use of bandwidth not over 10 KC in order to prevent interference with the signals of adjacent channel transmitters operating within the same service area.

Interference due to Frequency Shift

The radio broadcast transmitters must transmit the carrier frequency at the assigned frequency and has a tolerance which is established by International agreement maintained within 20 cycles of that assigned frequency. If the radio broadcast transmitters transmit the carrier frequency outside the assigned frequency and its tolerance, it will cause a mutual interference with the adjacent channels.

Interference due to Modulation Characteristics

The process of amplitude modulation is quite similar to the process of mixing. Other terms which refer to the same process are frequency changing, beating, heterodyning, and etc. In all cases, two frequencies are applied to a circuit, and at the output there appear the sum and difference of the two frequencies in addition to the original frequencies.

In radio broadcast system amplitude modulation is a process of combining an RF carrier and an audio modulating signal. Because of the heterodyning action which results, with the subsequent "beat frequencies," there are produced new frequencies equal to the sum and difference of the radio and audio frequencies involved. These new frequencies are known as "side frequencies" or "side bands." Therefore the RF signal is represented as a carrier with a similar spectrum on either sides. The total width is twice the highest audio frequency to be transmitted. As the maximum undistorted power output of a transmitter is obtained with 100 per cent modulation, it is generally desirable to operate with such a fully modulated carrier wave. If the modulation is less than 100 per cent, the power output is reduced, even though the power of the carrier wave has not been reduced. If the modulation exceeds 100 per cent, this reduces the carrier output to zero value for an appreciable period of time during which the modulating signal has definite amplitudes. This condition is called over modulation.

At over modulation, while the carrier is thus reduced to zero, the audio signal intelligence is not being transmitted, i.e., it is lost. The result was distortion in the waveform of the radiated intelligence. This represents an undesirable sidebands and carrier frequency shift, which in turn cause an interference on adjacent operating channels. Thus, over modulation is usually avoided in aural broadcasting service since it produces undesired distortion of the signal.

The modulation capability of a transmitter is the maximum percentage to which that transmitter may be modulated before spurious sidebands are generated in the output or before the distortion of the modulating waveform becomes objectionable. The highest modulation capability which any transmitters may have is 100 per cent modulation. The maximum permissible modulation of many transmitters is less than 100 per cent. The ITU and FCC regulations specify that no transmitter be modulated in excess of its modulation capability.

Distortion in Amplifiers

Ideally, the output voltage of an amplifier should have the same waveform as the input signal. Changes in the waveform are due to distortion. There are three types of distortion that may occur, either singly or together in any combination. They are nonlinear (amplitude) distortion, frequency distortion, and phase distortion.

Nonlinear Distortion

In ideal requires that the dynamic characteristic of the amplifier circuit be linear over the range of operation. Actually, the dynamic characteristic of the amplifier circuit is not linear in general but contains a slight curvature. This nonlinear characteristic arises because the (i_b, e_b) static characteristics are not equidistant lines for constant e_b intervals over the range of operation. The effect of this nonlinear dynamic characteristic is a nonsinusoidal output waveshape when the input wave is a sinusoidal. Such an effect is known as nonlinear, amplitude or harmonic distortion.

If a pure sine wave is applied to the grid of a vacuum tube operating with correct voltages and load impedance and the amplitude of the sine wave is such that it does not overdrive the grid, a pure sine wave can be expected at the output of the tube. The only departure from the original waveform of the input will be an increase in its amplitude and a phase reversal of 180° between the input and output circuits. (Fig. 1.)

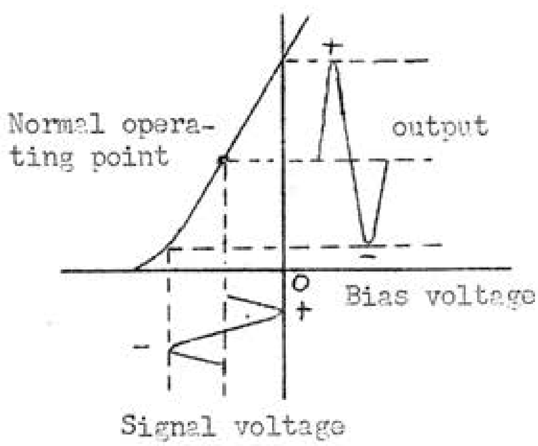

Fig. 1 — Plate-current characteristic of a triode biased for Class A operation.

When the bias is too large, the negative bias has been increased until the operating point has shifted downward toward the bend in the lower portion of the dynamic characteristic. Under this condition if a sine wave is applied to the grid, a greater amount of plate current will flow on the positive half of the grid swing that for the negative half and an unsymmetrical waveform will result in the plate-circuit shown in Fig. 2.

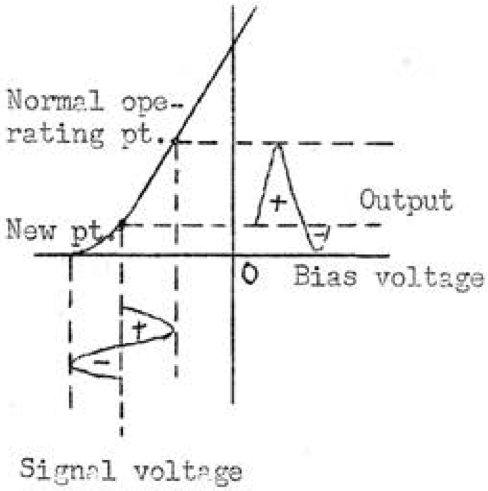

Fig. 2 —— Distortion of plate-circuit waveform caused by over-biasing.

If the bias voltage is too small, the negative bias has been decreased until the operating point has shifted upward in the dynamic characteristic. If the grid swings positive, the amplitude of the positive half of the plate-current waveform will be less than the negative half as shown in Fig. 3.

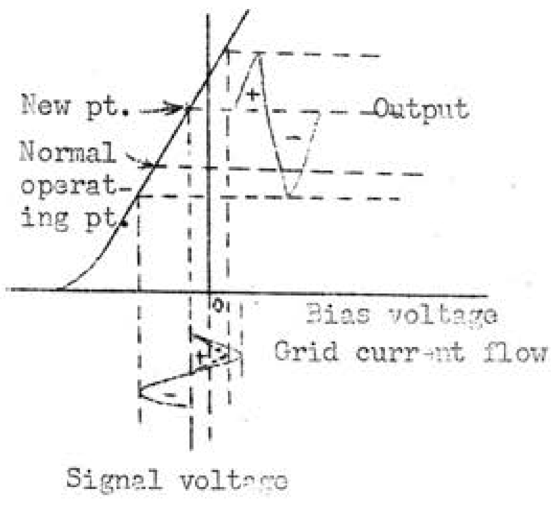

Fig. 3 —— Distortion of plate-circuit waveform caused by under-biasing.

When the grid is driven the zero point, grid current will start to flow because the grid is now positive with respect to the cathode. The flow of the grid current will cause a voltage drop across the load in the grid circuit which will be in opposition to the signal voltage on the grid, and the amplitude of the signal-voltage positive-going peaks will be reduced. The region is indicated by the dotted line in the positive half of the signal voltage at the grid. (Fig. 4.) Under these condition, second harmonics will be generated in the plate-circuit.[1] It becomes apparent that the bias voltage on the grid and the amplitude of the applied signal voltage are the controlling factors in the generation of harmonic distortion within a vacuum tube.

Harmonic distortion can also be generated within a vacuum tube that is correctly biased. (Fig. 4).

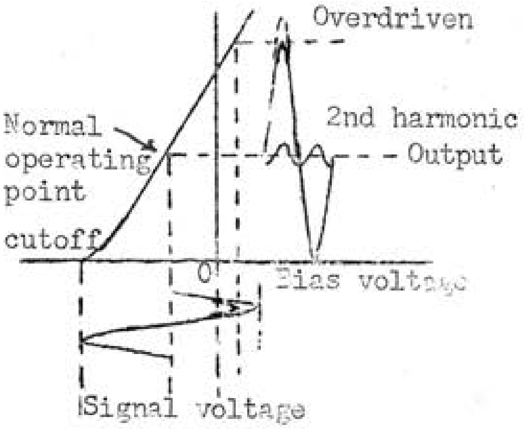

Fig. 4 —— Harmonic distortion generated in a vacuum tube that is correctly biased, but overdriven by too large a signal voltage.

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[1]Howard M. Tremaine, Intermodulation and Harmonic Distortion Handbook (Indianapolis: Howard W. Sams & Co., Inc., 1963), p. 11.

It should be noted that the signal voltage applied to the grid is large enough to extend into saturation areas of the dynamic characteristic. In the saturation region the peak of the output waveform is flattened since the tube cannot supply further plate current. In the negative region the flow of the plate current is reduced to a near cut off value. Thus, both the positive and negative peaks of the plate current waveform are distorted, and both odd and even harmonics are generated.

Frequency Distortion

Frequency distortion exists when all frequencies are not amplified by the same amount. It is due to the nature of the circuits associated with the tube. Frequency distortion occurs in some frequency range. The tube may cause frequency distortion if the period of the applied signal is of the same order of magnitude as the time of flow of the electron from the cathode to the plate of the tube.

Phase Distortion

Phase distortion occurs when the phase relations of the component frequencies being amplified are not the same in the output as in the input signal, even though both may contain exactly the same frequency components in the same relative magnitudes.

Phase distortion is not important in audio systems because the human ear does not distinguish small changes in the relative phases of components of a sound.

Adjacent channel Interference from High-order Side Bands

The output of a radio broadcast transmitter will interfere with adjacent channels if the output contains high-order side bands. High-order components can result from overmodulation of the transmitter or from distortion in the audio-modulating system that causes harmonics of high audio frequencies to be modulated on the carrier.

Interference due to Spurious Emission

It is important that 99 per cent or more of the radiated power lies within the bandwidth permitted for each class of service. Spurious out-of-band radiation can seriously interfere with other services. The most common type of spurious radiation is on frequencies which are multiples or harmonics of the desired frequency.

Interference due to Intermodulation

Interference due to intermodulation is a result when the second harmonic of one signal and the fundamental of any other signal combine to produce a difference frequency equal either to the frequency to which a receiver is tuned.